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Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

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Improved Wood

WOOD is a very wonderful material, generally extremely strong, almost always beautiful and very workable by the human hand into lovely forms. It is not surprising that since the dawn of time it has retained a high place in the list of our materials of construction.

But it is not an ideal material because of the very fact that it is a natural growth, becoming larger in two directions, it is true, but with strength lying only in one. Along the grain it is quite weak and, as somebody has already said, it would be a finer stuff if only trees grew without branches and without roots; meaning, we presume, that knots spoil many a plank. Furthermore, wood absorbs large quantities of water and warps with the changes in weather. Since also cellulose and water and the salts contained therein are quite good foods for certain types of life, wood is readily attacked throughout its existence in all its forms by many bacteria, fungi, and a host of insects which, in the course of time, rot it and pulverize it. Little wonder, therefore, that for thousands of years mankind from Noah onwards has tried to prevent these ravages by treatment with bitumen, coal-tar compounds like creosote, special preservative salts, etc. These materials do, in fact, preserve wood very effectively, but it can scarcely be said that they give it greater strength; they merely prolong the life of the wood. A creosoted railway sleeper is not stronger than the original timber, but it can last for 50 years and remain strong all the time. However, it cannot be considered a thing of beauty—it cannot even be painted.

The aim of mankind has been to go much farther. The ancient art of veneering wood, now at a high state of perfection, was the first step in this direction and by laying the plies alternately at 90 degrees an almost unbreakable structure was obtained. Unfortunately, the weakness of plywood lay in the glues employed, and since they were invariably of animal or vegetable origin, they, too, were liable to attack by organisms and insects. Thus, while plywood was much stronger than wood it broke down at the joints and the plies came apart with time.

The chemist of the twentieth century, by the introduction of synthetic resins, lays a fair claim to having provided the cure for most of these ills. His synthetic glues, as typified by the phenol and urea-formaldehyde type, are not only stronger glues, but are virtually indestructible. By their means plywood itself is enabled to leap out of the rather narrow rut it had delved for itself and rightly claim a seat beside the mighty metals of construction.

It is not only the plywood industry that has benefited by the new discoveries. The electrical industry rapidly seized upon the chance of improving plywood for electrical structures, and by going a step farther has employed the resins not only as glues, but as dielectric impregnants producing non-conducting structures far surpassing in strengths those of the older materials. The electrical industry has, in fact, entered the plywood industry. It is reasonable to suppose that the aircraft industry will follow suit.

Another fascinating and economically valuable process is a still further step taken by industrialists—the impregnation of plywood with resin, followed by high compression. This method, as typified by the Samsonow process (which will be described in our next issue), results in an indeed improved wood, capable of becoming the ideal material for the root of a variable-pitch airscrew.

It has seemed that the impregnation of solid wooden blocks should be a logical step in the production of improved wood. This has, indeed, been done in Germany with some success, and we remember well the work of the late Professor W. E. Gibbs and Mr. Brajnikoff in this country on the same lines. This process of impregnating under pressure or vacuum, or both, is extremely difficult and results have not yet reached an entirely satisfactory point. The laminated variety holds the field at present, but it is obvious that impregnated wood structures are tremendously strong across the grain. Very large bearings have been made with it and used with success. We believe the German Lignostone was of this type.

In the pages of this issue we show some of the developments that have taken place with plywood, and in following issues we hope to continue them.

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Spinning the Plastic Yarn

FOR the sum of sixpence the public of this country can now read the story of plastics, told in as fascinating a manner as we have ever encountered. "Plastics," by V. E. Yarsley and E. G. Couzens, has just been published in the Pelican series, those rather sober blue-covered relatives of the Penguin group.

Dr. Yarsley, who knows as much about the subject as anybody in this world, and Mr. Couzens, who is assistant factory manager B.X. Plastics, Ltd., have done something very remarkable for our industry in writing this book. It is not only extraordinarily meritorious in getting such a story—a purely industrial one—published by such a house as Allen Lane, but for the first time we see a real effort to get the public plastic-minded by such a medium. If this effort succeeds, even to a small degree, the economic effect on the plastics industry will prove tremendous.

There is no necessity to detail the contents of this book to readers in the plastics industry since it covers the whole field and since the value of it lies in the manner in which the story is told. It is sufficient to give the title of one chapter "Why Are Plastics Plastic?" to show they know what readers want.

Like many journalists before them, Yarsley and Couzens are firm believers in the impending "Plastic Age" and give us the seven ages of the future "Plastic Man." They differ from the average journalist, of course, in knowing what they are talking about. Their Plastic Man, while apparently not yet synthetic, nevertheless is born in a world of colour and plastic cleanliness, devoid of breakable and cutting things and where nearly all implements, clothes and most utensils are of plastics. Even at school he will have the privilege of being beaten with a synthetic plastic cane tougher and more resilient than the natural type. (We might suggest here that the "plastic infant" would already have had the intelligence to stuff the seat of his pants with a polyvinyl chloride quite able to absorb such shocks.) And so on through life, in the home and in the office the Plastic Man will be surrounded by our materials until "he sinks into the grave hygienically enclosed in a plastic coffin." We should not ourselves have ended there. Could he not be wafted aloft on cellulose-acetate wings to spend the rest of his immortal life plucking at the strings of a moulded-resin harp and dusting with nylon brushes the transparent, gold-flecked, cast-resin stairs?

Exporting British Plastics

WE have just received a copy of the Export Catalogue which has been compiled by the Plastics Export Group. It is a truly fine compilation, sensibly arranged, and so beautifully and clearly drawn up that buyers will find no problem in understanding what the British plastics industry has to offer. On page 93 we reproduce four of its pages, which are self-explanatory. There are 39 of these, covering table-ware, kitchen-ware, containers, fancy goods, toilet articles, smokers' requisites, desk accessories, door furniture, furniture and furnishing accessories, lavatory fittings, jug and other handles, lamp shades, torches, games and articles of sport, toys and miscellaneous articles. In addition there are coloured photographs showing the different colours in which the mouldings are available and photographs of industrial mouldings which range from electrical units and pump impellers to radio-cabinets and electrical heaters. As will be seen from the pages reproduced, all the photographs are at the head of the page and are followed by numbered descriptions in English, French, Spanish and Portuguese. Sir Andrew Duncan, President of the Board of Trade, writes a very adequate introduction, and Dr. Yarsley contributes a bright article on the plastics industry.

In order to avoid competition amongst members' agents, the Group has appointed, in conference with the Department of Overseas Trade, joint agents and sub-agents, who will act in their respective territories throughout the world as the representatives of all the 45 members. Each of these agents is being provided with a considerable quantity of copies of the catalogue, together with samples of the illustrated mouldings; and minimum export selling prices have been agreed amongst the members in order to eliminate competition still further.

In wishing these catalogues God-speed, we can congratulate the Plastics Export Group with doing something that seemed very difficult in peace-time. It has united a large section of the plastics industry to think as one and has brought order out of what might easily have been chaos. We shall reap a still greater benefit after the war. We may also be grateful for the existence of the British Plastics Federation, without which nucleus the growth of such unity would have been rendered extremely difficult.

THE BATTLE FOR BRITAIN.—We suppose most of our readers have read by now the greatest thriller of all time, the story of how the R.A.F. smashed the Luftwaffe. Most Londoners will for ever remember that Sunday of September 15, the greatest day of all, when over 400 German aircraft in a last effort to crush our resistance lost 43 per cent. of their strength and fled back to their aerodromes "a shattered and disordered Armada."

It is a thrilling story of a dangerous period, and yet while we read it we could not help giving a squeak of delight at encountering a new word that has entered the vocabulary of our pilots. It is not a new word to our readers, although it is to most outside our industry, so that we feel we share a little secret with the pilots. In a description of that day's fight a pilot says ". . . saw an Me 109 attack me . . . I saw his perspex burst and the enemy aircraft spun down."

So the word "Perspex," the trade name I.C.I. (Plastics), Ltd., gives to its methyl methacrylate resin, has become a synonym in the R.A.F. for organic glass! Nobody will mind this very much, even its cellulose acetate competitors, and decidedly we shall not be pedantic and ask our pilots to call the German material by its real name Plexiglas, the trade name used by Rohm and Haas of Berlin, or Trolitul, the German cellulose acetate. Let it suffice that the "perspex" and the Luftwaffe were both broken on that wonderful day.

". . . I saw his perspex burst . . ."

Plywood has served the world well in the past, but its limitations have been many. To-day the scientist, by the production of synthetic resins, has transformed plywood into an indestructible material of far wider applications

FEW realize the extent to which plywood, often accused of being a poor substitute for noble timber, enters into our everyday lives, nor, indeed, the extent by which plywood has been improved since plywood first appeared in the world. To the plastics industry the main point of interest is how it has been improved.

It comes generally as a shock to find that plywood and the art of veneering is far from new, but that it was certainly practised by the ancient Egyptians, for examples of this work in the form of sarcophagi have been found in the tombs of the Pharaohs. Records do not relate details of the condition in which they were, but even using the animal glues of those days, no deterioration by moisture or bacteria need be expected in the dryness and air stillness of those burial grounds. However this may be, the common modern conception of plywood conjures up a piece of tea-chest which has been left to weather and is decidedly the worse for wear.

Doubtless plywood was far from being, 10 to 15 years ago, the almost indestructible material it has to-day become. Invariably animal and vegetable glues and starches and blood albumen were employed to stick the plies together, and all suffered to some extent from attack by moistures and fungal and bacterial invasion which lead to breakdown. It is true that a vast improvement was made by the coming of casein glues. They are easily applied in the cold, need no heat to complete the jointing and are extremely cheap. None of the foregoing, however, can stand up to very high tensions, torsions or shear, and all are liable to bacterial attack.

The greatest advance was made with the advent of synthetic resins of the phenol-formaldehyde and urea-formaldehyde type, for here, indeed, is a bond even much stronger than the wood it binds and completely unattacked by moisture, fungus and bacteria. By their means the value of plywood as a structure for building and general construction has been enormously enhanced. Plywood now takes its stand, for strength and permanence and light weight, beside many of the older materials of construction.

The value of the phenolic resins as glues (usually in 50 per cent. solution in methylated spirits) was soon apparent following the production of electrical units, tubes, sheets, etc., by impregnating paper in such solutions. These solutions may be utilized as such by brushing direct on to the wood surface or by application through a roller-coating machine of the usual type. Yet another method of applying phenolic resin glue introduces the brilliant idea of a dry thin sheet (made by dipping tissue paper into phenolic resin alcohol solution and drying) placed between the plies, followed by the application of high temperature and pressure to complete the bonding and hardening of the resin. This dry sheet has been available in Great Britain during the past few years under the two trade names of Plybond (Bakelite, Ltd.) and Tego Gluefilm (British Tego Gluefilm, Ltd.), and has, to a considerable extent, revolutionized the plywood industry.

Almost contemporaneously the value of the urea-formaldehyde liquid glues was discovered for similar purposes and about four years ago its production was commenced in this country by British Industrial Plastics, Ltd., who make a series under the name of Beetle Cements. A fuller description of these is given on another page in this issue.

Now to turn to one of the foremost plywood manufacturers in the country and to observe how and where they use the synthetic resin glues.

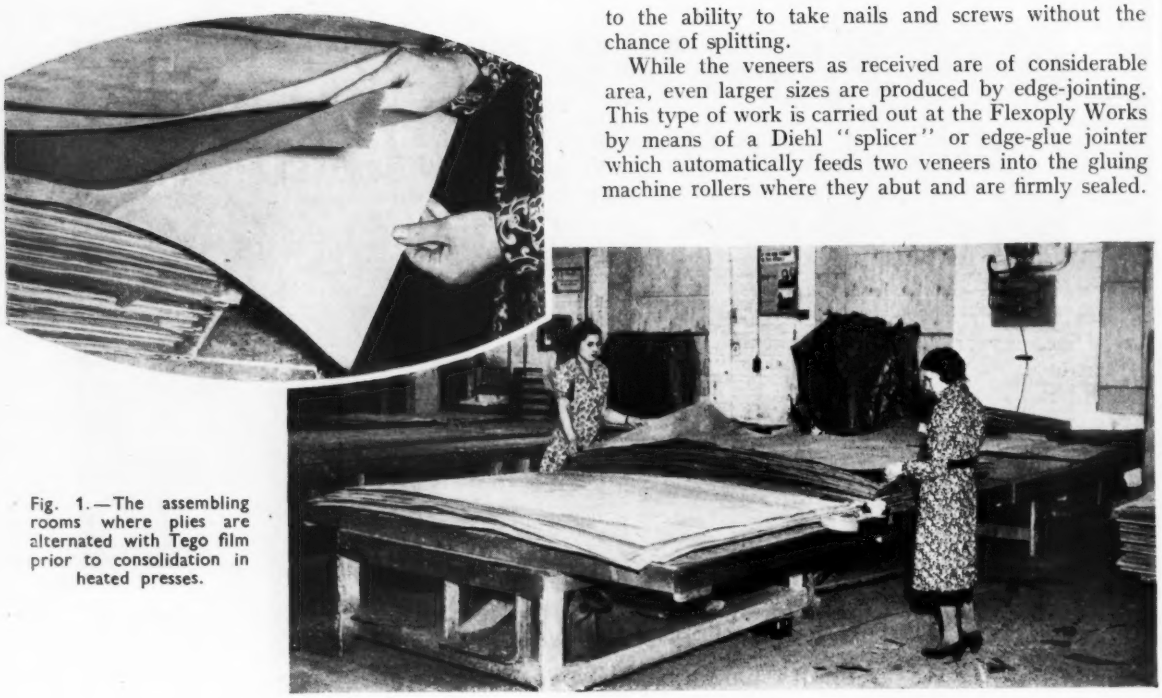


Fig. 1.—The assembling rooms where plies are alternated with Tego film prior to consolidation in heated presses.

Flexo Plywood Industries, Ltd., of London, have long been among the most important of British producers. Their success has not merely been concerned with the production of decorative wood veneers such as panelling, flush doors, pipe ducts, lift cages, etc., of which they are master producers, but also with that very beautiful art of facing plywood with metal for decorative and utility purposes. From stainless steel covered plywood for hospital trolleys and writing desks to lovely copper-covered pelmets for window hangings the field is as wide as it is important.

As is probably well known, almost any size (that is, in area) of panel of plywood can be built up from the thin veneers. Thus, complete panels $\frac{1}{2}$ in. thick by 34 ft. by 7 ft. 6 ins. have been successfully made.

The structures are built up to the required thickness with layers of veneer approximately $\frac{1}{16}$ in. thick, the grain of each layer crossing the adjacent one at an angle of 90 degrees. When bonded this alternating cross-grain structure is thus equally as strong with and against the grain, a situation that does not obtain in the original lumber. This added strength also applies to the ability to take nails and screws without the chance of splitting.

While the veneers as received are of considerable area, even larger sizes are produced by edge-jointing. This type of work is carried out at the Flexoply Works by means of a Diehl "splicer" or edge-glue jointer which automatically feeds two veneers into the gluing machine rollers where they abut and are firmly sealed.

From this point the veneers reach the assembly tables where the veneers are arranged at 90 degrees alternately and interleaved with Tego film sheets of equal area preparatory for consolidation and curing. In Fig. 1 the assembly of Canadian birch 10 ft. by 7 ft. is seen being made. At this point it may be pointed out that successful bonding depends on the proper control of the moisture content of the veneers, of the temperature during pressing, the surface pressure itself and the time this is maintained.

The large press shown in Fig. 2 is supplied with a number of "daylight" platens, between each of which are placed the assembled ply-glue film stacks. Plywood "cauls" are used on both sides of the stack to facilitate loading and to retard heat penetration until full pressure has been applied.

To the right of the press are seen the Cambridge instruments, which record and control temperature and pressure. A temperature of about 140 degrees C. and a pressure of 250 lb. per sq. in. is a good example of the conditions generally employed. The curing and consolidation is complete in about half an hour.

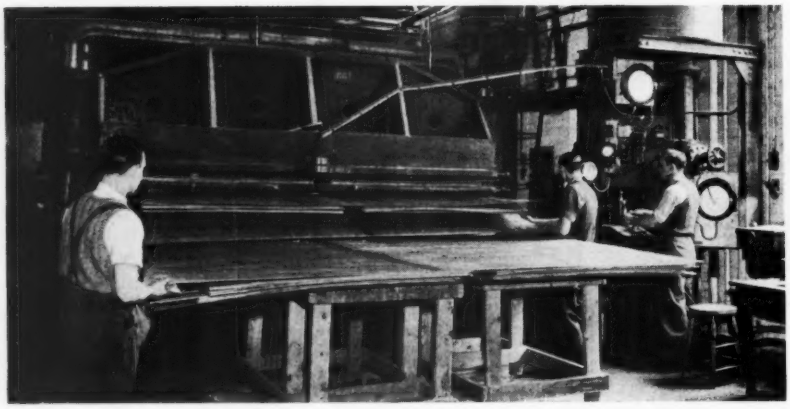


Fig. 2.—The large press where the stacks of plies and resin film are consolidated under heat and pressure.

The bonded structures are removed and are then dealt with according to their ultimate life; this is, they are sawn into shape, sanded, polished, and so on.

Experience with plywood in peace-time has helped the war effort to a remarkable degree. It is especially worthy to record its use as it affects the marine industry. Several years prior to the war Flexoply had been employed in the construction of speedboats. One of them, "Jeep," won the International Trophy of the Oulton Broad Motor Boat Club.

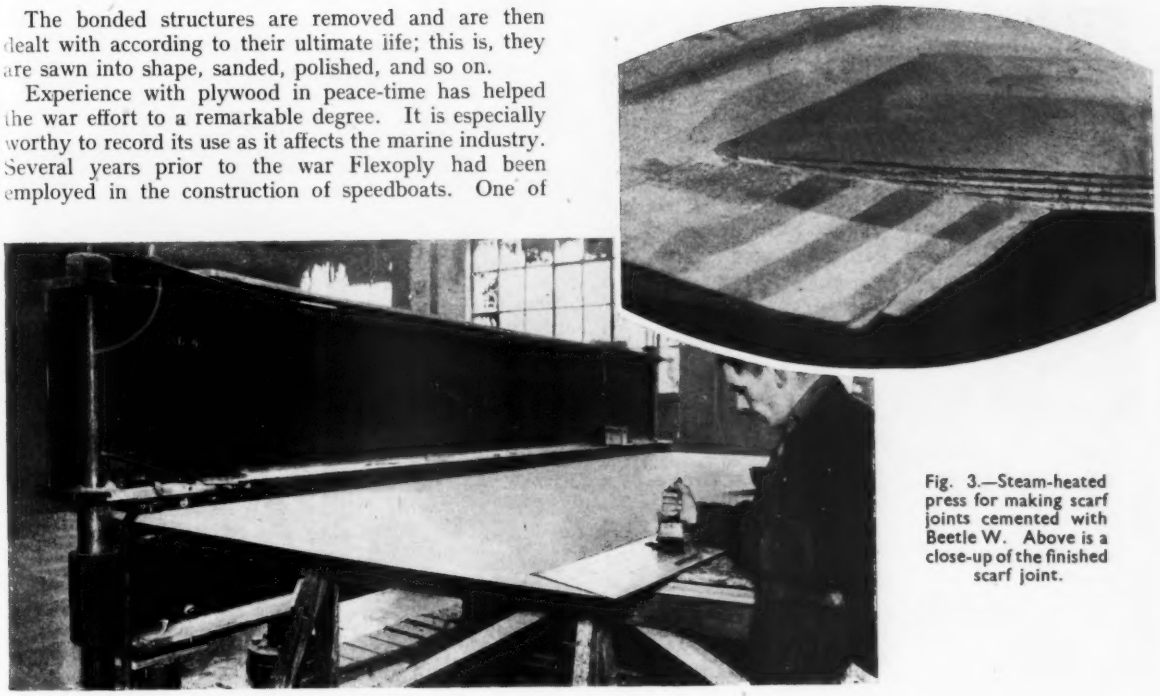


Fig. 3.—Steam-heated press for making scarf joints cemented with Beetle W. Above is a close-up of the finished scarf joint.

One particularly interesting case is the construction of a number of light patrol boats. A fleet of such boats was required quickly and supplies of seasoned timber were scarce. A naval architect with vision, a well-known firm of motor engineers with foresight and the courage of their convictions, and Flexo Plywood Industries, Ltd., with its modern plant, got together, and a very handy little patrol boat was evolved. One day it is hoped that the full story may be told, but all that can be said at present is that these boats are coming off the slipways at mass-production speed with frames, stems and engine bearers of resin-plywood.

The frames are produced in the factory roughly to shape and sent to a central depot, where they are cut more accurately to template, including notching for stringers, etc. A set of frames, together with a prepared keel with frame stations marked thereon, is despatched, the keel is laid and the frames erected.

To avoid wastage of plywood, the frames are produced with comparatively narrow strips of ply 18-30 ins. wide and joined together with accurately made "scarfs" at an angle of 1 in 8. These scarfs are cemented together in special hydraulic presses, using a urea synthetic-resin cement (Beetle W.), with which the plywood itself is bonded. Although similar scarf joints had been used for years in producing super-size panels for the motor coach and tramcar body industries, they were at first looked on with some suspicion in the marine world, but providing they are made with a reasonable degree of accuracy and assembled with correct cement, they are definitely not a source of weakness. Just recently this has been proved by a series of tests, by an independent Test House, on pieces cut from production runs. Test figures show that breaking loads on 1-in. Canadian birch ply are as follow:—

	Unscarfed. lb. per sq. in.	Scarf jointed. lb. per sq. in.
Tensile	7,270	8,040
Compression	9,340	8,070
Bend test; modulus of rupture	13,270	13,666

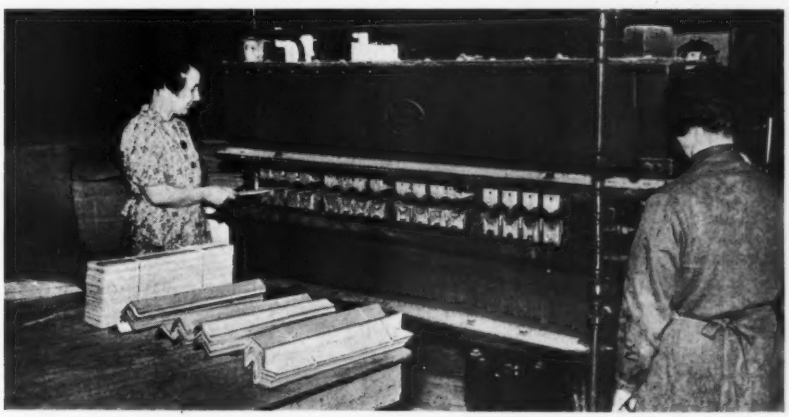


Fig. 4.—An interesting type of press (John Shaw and Sons, Ltd.) used for making aircraft fillets from small strips of resin-bonded plywood.

Flexo veneered panelling and flush doors. Each wall is covered with one piece.

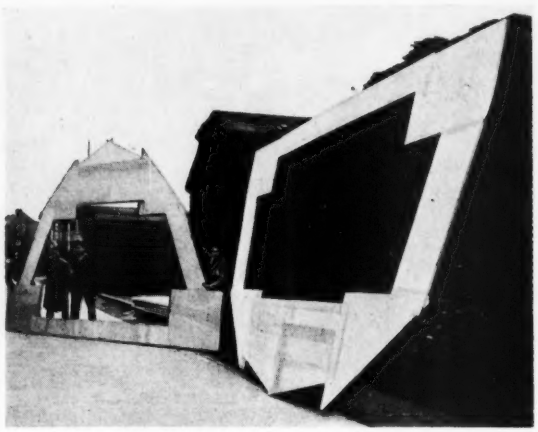
Seasoned timber suitable for boatbuilding will be even more scarce when our present troubles are over once again, and it would seem that this product of modern times will be our salvation when our thoughts turn once again to the design of that "dream cruiser."

Plywood for frames, bulkheads, coamings, decks, cabin soles and engine bearers is already a practical possibility. As planking for a hard-chine construction plywood is also ideal.

For round bilge work, however, plywood does not readily lend itself to the severe compound curves required, but here, again, considerable research and development work is in progress in the manufacture of panels moulded to the required shapes.

The preceding notes give some slight indication of the modern activities of our plywood industry. It is destined to play an ever-increasing part in our everyday life.

We have pleasure in thanking Mr. H. P. Martin for permission to visit the works, and Mr. Simmons for his exposition of the plant and its working.



Frames for patrol boats constructed from scarfed plywood bonded with resin.

Preserving Snowflake Forms

A SIMPLE method for preserving permanently the crystal beauty of snowflakes has been revealed by Vincent J. Schaefer, of the General Electric Research Laboratory, in an article in the magazine *Science*.

By covering a snowflake with a drop of a solution of Formvar, a transparent plastic resin often used for electric insulation, and allowing the drop to dry, Mr. Schaefer found, a permanent cast of the snowflake crystal can be obtained.

Though the film remaining is only about eight one hundred thousandths of an inch in thickness, he reported, it preserves the characteristic hexagonal snowflake features in the most microscopic detail for later photographing or microscopic study. No two snowflake crystals are ever exactly alike.

"A strip of velvet or other dark material fastened to a board or table, a few glass microscopic slides, a toothpick or wire, and a weak solution of a suitable resin are all the equipment necessary," explained Mr. Schaefer. "The only other essential is an occasional snow flurry. As soon as a suitable flake is observed on the dark background, a drop of solution is placed on the glass slide with the toothpick or wire, and the flake is lifted with the same tool and placed in contact with the drop. The solution should wet the flake completely. A second drop placed on top of the snowflake is sometimes desirable, particularly if the flake is of large proportions. After wetting the flake in this manner the solvent soon evaporates, leaving the snowflake encased within a shell of resin.

"A 1 per cent. solution of polyvinyl formal resin, designated as Formvar 15-95, dissolved in ethylene dichloride and cooled below freezing was found to produce excellent replicas. The thickness of such a replica is of the order of 20,000 Angstrom units. As soon as the solvent has evaporated, the slides may be removed to a warm place. The case may be protected from abrasion by covering with a transparent sheet of resin or a glass cover-slip or slide. The casting materials can be carried anywhere, thus greatly increasing the possibilities of obtaining unique specimens.

"A slight modification of the method provides an equally easy way to make a permanent record of breath patterns and any other structures, such as frost crystals, hoar frost and similar perishable formations. After the molecular films are deposited on the plate, it is placed in the freezing compartment of a refrigerator, and upon cooling to about 10 degrees centigrade, is held for a brief moment in the presence of moist air (which forms the so-called 'breath patterns'), replaced in the ice chamber and the breath pattern is frozen. Meanwhile, the 1 per cent. solution is cooled below freezing. The plate containing the frozen breath pattern is then dipped into the solution, removed and returned to the cold chamber until the solvent evaporates. A perfect replica of the breath pattern remains after the plate is warmed and the water evaporates."

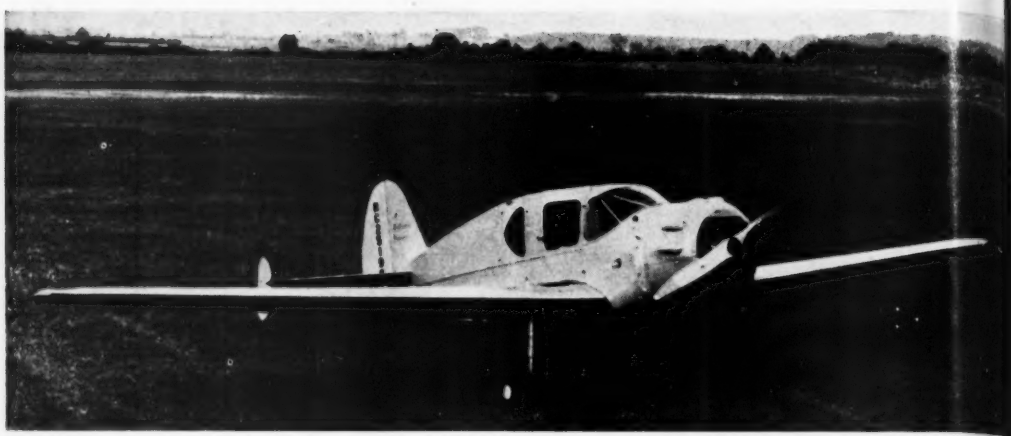
Mr. Schaefer has long made a hobby of photographing ice formations. He is an assistant to Dr. Irving Langmuir, who received a Nobel Prize in chemistry for pioneer research.

Bettix, Ltd.—This concern has now removed to Arrow Works, Elm Grove, Worple Road, Wimbledon, S.W.19, and has asked us to remind readers that they are fabricators and formers of cellulose acetate, Perspex and laminated pressings, and also carry out every kind of injection moulding.

British Plastics Export Group

Four specimen pages taken from the catalogue which will be distributed to importers abroad

BRITAIN can deliver the goods and the plastic industry of this country is making them. Hundreds of these catalogues are being sent to North and South America, to Africa and Asia, to show the buyers of the world what we have to sell



Right: Bellanca "Cruisair," much of which is constructed of wood plies bonded with a resin adhesive.

Plastic-bonded Plywoo

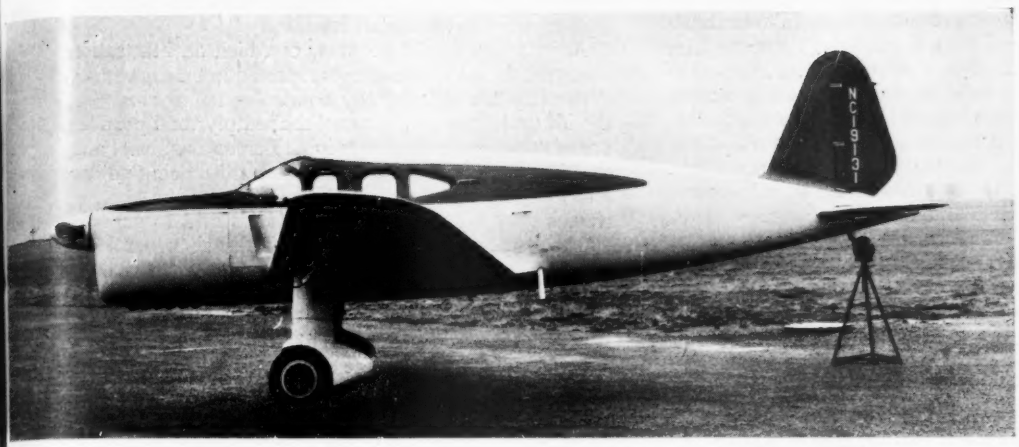
Left: Wing panel for Model 14-9 Bellanca "Cruisair," using phenolic resin setting at low temperature.

Right: Nacelle produced by the Duramold process by the Haskelite Mfg. Corp. for the Glenn L. Martin Co.

MUCH is heard to-day about so-called "plastic" aeroplanes. They are more properly referred to as plastic-bonded or resin-bonded plywood planes, for the plastic or resin employed is used only as an adhesive to bond the plywood. Application of heat and pressure, however, cause the plastic or resin to flux and to be forced into the cellular structure of the wood. As the plies are usually quite thin (the thickness used in the U.S.A. usually being from 1/48 to 1/20 in. in thickness) the whole texture of the wood may be quite fully impregnated with the resin, depending in part upon the quantity of resin applied. Some 10 to 14 per cent. of resin, by weight, is reported in use in one of the most important American processes.

Plastics has already given considerable space to certain of the processes used in fabricating American aircraft parts, especially the Timm "Aermold" process, but, as yet, little about other processes has been available for publication, and, of course, much cannot now be revealed. Some facts have been made available in American publications, and a summary of these, or the more important portions, is here given. Particulars not yet released naturally have to be omitted.

In the Duramold process, as first developed, use was made of a male mould or form constructed of cast iron and cored with steam passages, as shown in an appended sketch. The form in some cases yielded a half shell for a nacelle or its equivalent. Plywood was laid over the form, with the grain crossed in alternate layers, and between the plies there was applied the resin or plastic for bonding purposes. When a sufficient thickness was built up the whole was covered with a heavy rubber bag shaped as required. Over the bag was placed a steel shell, and the latter was held to the mould by straps with threaded ends to receive nuts. Then the bag was inflated with air, thereby clamping

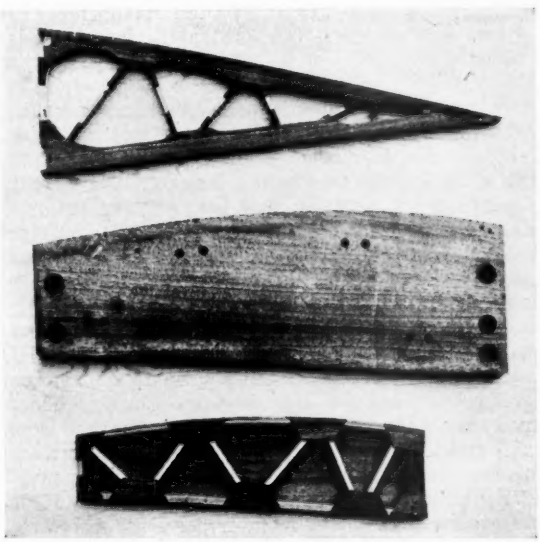


Left: A Duramold fuselage was employed in this experimental plane, the "Model 46" Fairchild.

Below: Wing structure fabricated by Bellanca Aircraft Corp. using phenolic resin binder.

oo tructures for Aircraft

Details of Some of the Methods which American Aircraft Manufacturers are Applying to the Construction of the So-called Plastic Aeroplane



Left: Typical ribs produced by Bellanca, bonded with phenolic resin.

the plywood layers against the mould under pressure. Steam admitted to the mould, via its cored holes, supplied the heat, which in time permeated the plywood, fluxing and setting the resin and moulding the shell to the required shape.

This process is now abandoned because the moulds are expensive, the method of heating slow, and any irregularities, such as may be caused by differences in the thickness of plies or joints therein, appear in the outer surface, because the bag filled with air is the yielding member. The process did, however, do away with the need for a normal moulding press.

Better and less expensive is the method now used. In it the mould is female and is made from thin sheet metal, such as ⅛-in. Duralumin sheet, which is highly polished and correspondingly smooth. This sheet is provided on its outer surface with a stiffening framework, which holds it in the required shape but need not be very heavy. Plywood is then fitted in layers into the mould, and between the layers Tego film (tissue paper impregnated with phenolic resin) is placed. If necessary the plywood is cut in gore-shaped strips to facilitate placing it, without wrinkles, in areas which have a double curvature; in this case a liquid resin adhesive may be more convenient than the Tego film. For convenience, adhesive tape is sometimes used to hold laminations in place until they are bonded by moulding. The number of layers is varied to meet requirements and need not be uniform over the entire area. In fact, it is common to vary the thickness more or less in proportion to the stress or degree of rigidity required, so as to minimize weight.

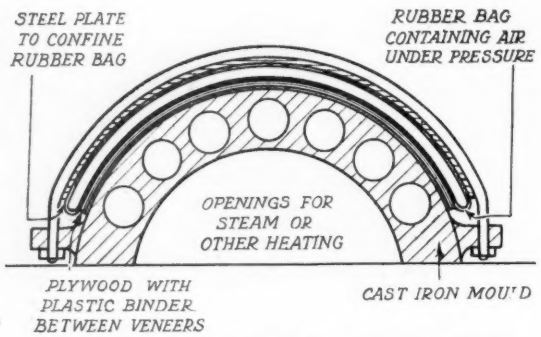
When the mould is thus charged the plywood is covered with a rubber blanket, and the latter is clamped against the edges of the mould, sealing the charge between the mould surface and the blanket. In pre-

paring the charge, however, minute thermocouples are embedded in the thicker sections, midway in their thickness. Fine wires from these are led out between plies, and are later connected to electrical instruments calibrated so that they indicate the temperature at the points where the thermocouples lie. After the mould is sealed, all air is exhausted from the space in which the charge is located, and the mould is placed in a steam tank, or autoclave, and the door of the tank is sealed. Steam is then admitted and creates pressure on both sides of the mould, that is, against the blanket on one side and the sheet metal of the mould on the other side. As the pressure is uniform over the entire surface, it is balanced and there is no tendency to distort the mould.

Moulding Conditions for Duramold

Pressure is raised to about 100 lb. per sq. in., and, as the steam has a temperature of about 300 degrees F. and the resin used fluxes at 280 degrees F. maximum, the required bond is effected, heat entering the plywood through both the mould and the blanket.

If the moulding formed has a maximum thickness of ⅜ in., the time required in the autoclave is about 10 to 12 minutes. It is less for thinner mouldings and greater for thicker, but in all cases the curing continues until the thermocouples show that the required temperatures have been attained in the thickest sections, thus ensuring complete fluxing and firm bonding at all points. The steam is then turned off and the pressure reduced to atmospheric, after which the autoclave is opened and the mould removed, with its charge. In at least one case a tank 10 ft. in diameter and 30 ft. long is in use, making it possible to mould a full half covering for a wing and other parts of similar size.


STEEL PLATE TO CONFINE RUBBER BAG
RUBBER BAG CONTAINING AIR UNDER PRESSURE
OPENINGS FOR STEAM OR OTHER HEATING
PLYWOOD WITH PLASTIC BINDER BETWEEN VENEERS
CAST IRON MOULD

Section showing moulding system used originally in the Duramold process. It has now been superseded.

Ribs and spars can be built up by similar means, but details are withheld at present. It can be said, however, that spars are being fabricated from short lengths of ⅜-in. spruce and from other woods. At the ends of the short lengths scarf joints are made with phenolic adhesive and a similar joint between the laminations. This makes it possible to utilize short straight-grained pieces and to insert spruce, which is not plentiful, only at such locations as its favourable properties are required, using other more plentiful and less expensive woods for other portions. Planks up to 2½ ins. in thickness are made in this way, but their great thickness requires a cure of some two hours to permit the required temperature to be attained at the centre and thus ensure proper bonding. Both the scarfed joints and those parallel to the faces are said to have a strength at least equal to that of wood itself, and by proper selection of the wood the spars are without flaws. After a plank is formed in this manner it can be sawn, of course, into square or other sections. Curved as well as straight spars are made.

Complete wing sections have been fabricated by moulding two halves and assembling them at scarfed joints. It is also possible to assemble ribs to the moulded coverings, but details as to how this is accomplished are not yet released.

Another Duramold product, of which an illustration is supplied, and which is now reported in extensive use, is flooring having integrally bonded stiffening ribs. As the illustration shows, channel-shaped plywood portions are moulded between the 1/16-in. stiffening members, and the floor itself is laminated, the core plies being poplar and the thinner ones birch in two layers. The flooring weighs only 0.7 lb. per sq. ft., but is said to support 400 lb. per sq. ft. of area. A specially shaped rubber bag is required to form the channels between the ribs, but otherwise the moulding is similar to that described above, although the "mould" is merely a flat plate. It is understood that some large parts, in addition to the flooring, fabricated by the Duramold process, are in production; certain of them are used in at least one make of military training plane, but again details are being withheld.

The Duramold process is reported to be controlled by the Fairchild Engine and Airplane Corp. and its subsidiary, the Duramold Aircraft Corp., at least, as far as aircraft applications are concerned, but the Haskelite Manufacturing Corp., makers of plywood products, have certain rights understood to be for parts other than for aircraft. Hughes Aircraft Division, Hughes Tool Co., a Pacific Coast aircraft manufacturer, is said to have been granted rights under Duramold patents for making large aircraft or parts thereof by the process, but to what extent it is being used by that company the writer does not know.

Next to the Duramold process, that known as the Vidal process seems to have attracted most attention, although details available concerning it are quite limited. Its name (see *Plastics*, January, 1941, page 1) is gained by its association with Eugene Vidal, a former chief of the Civil Aeronautic Authority of the United States Government and now associated with the Aircraft Research Corp., which, in turn, is said to be controlled by the United States Plywood Corp., one of the largest makers of plywood products. If any parts of aircraft made by the Vidal process are in production, particulars have not been given out and they are of quite recent development; but the U.S. Plywood Corp. is understood to be making boats by the process, on a production scale, and to be ready to produce other parts, presumably for aircraft also, once the experimental parts under development are ready for such production. At least one experimental plane, made largely by the process, has undergone extensive tests, as have seaplane floats some 20 ft. in length. Experimental fuselages for the Canadian Government are reported in progress or completed, and news reports from Canada indicate the early production in Toronto of what are termed "all-plastic" elementary and intermediate training planes, presumed to be a result of this development.

From such information as is available for publication it appears that the Vidal process is similar in some respects to the Duramold process in which a male mould

was used, although a rubber blanket or bag, presumably applied more as in the present Duramold process, appears to be used. One objective, however, is said to be to include stiffening structures, such as ribs, in the assembly when it is fabricated. These stiffening parts are said to be set into slots in the mould, but precisely how they are made and how joined to the main shell of skin is not revealed. Some of the moulds used experimentally, at least, are said to be of wood.

Methods of the Bellanca Aircraft Corp.

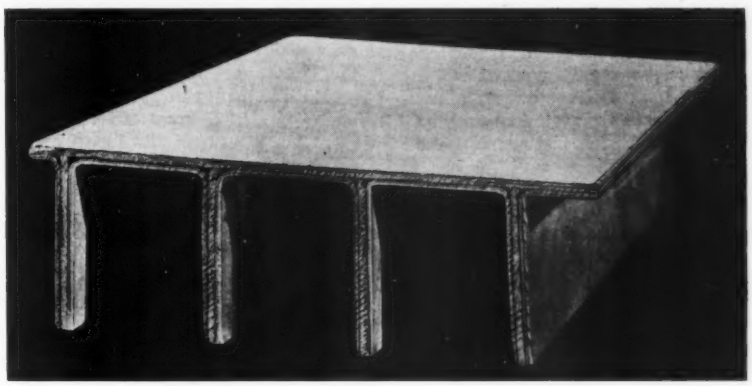
One of the Bellanca Aircraft Corp.'s engineers has given out certain information about aircraft parts which his company has produced by laminating with phenolic adhesives, but again details of the process are withheld. It is reported, however, that the laminating is done in somewhat the same way as with glues, using screw types of clamping devices to force the plies of wood together and to mould them to shape after the adhesive has been applied. Curing of the resin is helped by using an accelerator and by subjecting the assembly to baking or heating to a temperature of 140 degrees F. In this case the resin, supplied by the Catalin Corp., is of the water-soluble type, and it is applied in water solution to which is added, just before application, the accelerator supplied by the same company.

Adhesive prepared in this manner is said to have some cold-setting properties and will set hard at normal room temperatures in 24 hours, but if the piece being laminated is subjected to a temperature of 140 degrees F., curing is completed in two to six hours. Application of the resin solution, including the accelerator, is by brush or spray, and spreading and handling, as well as mixing, are similar to that for casein glue, as is the clamping required. Joints obtained, however, are much stronger, and the phenolic adhesive, when set, becomes insoluble and thereafter is not affected by moisture or even, it is said, by prolonged boiling in water. Since the temperature required for curing is so low, curing can be done, if necessary, in rooms rather than in ovens and with little or no heat insulation. It is not necessary to use an autoclave, since the pressure is applied with clamps. It would appear, however, that for large production many clamping forms would be needed.

This method of fabrication is understood to have gained the approval of the Civil Aeronautic Authority and of the United States Army for the Air Corps, of which planes are being built, it is reported by Bellanca. Some aircraft structures fabricated by the Bellanca method are here illustrated, and experimental panels exposed on a roof for a year are said to have shown no deterioration, although similar panels, fabricated with casein glue, disintegrated soon under the same exposure.

As the Timm "Aermold" process of fabrication has been described before in *Plastics*, details need not be repeated here. It may be said, however, that the final moulding is done in a metal mould, which is said to be "warmed" and that the pressure applied (whether by using a rubber blanket in a closed chamber or by other means is not stated) is 50 lb. per sq. in. The phenolic adhesive is believed to have some cold-setting properties, and the final curing occurs after the fabricated assembly is placed in an oven for baking. (See *Plastics*, October, 1940, for other particulars.)

From the foregoing it may be concluded that, although plywood planes bonded with resins, especially of the phenolic type, give much promise of success, they are still in or just emerging from the experimental state —at least, as far as developments here outlined are concerned. Some parts for aircraft have been made from resin-bonded plywood, however, in considerable quantities. The Glenn L. Martin Co., for example, which produced planes built largely from metal, is equipping some of its bombers with bomb bay doors 14 ft. long and weighing about 50 lb. These have a ⅛-in. plywood covering bonded with phenolic resin and consisting of a poplar core faced with mahogany. Ribs and some other parts are also laminated, but are bonded with a cold-setting urea-formaldehyde adhesive. Some Fairchild training planes are built with wing portions fabricated by the Duramold process.



Section of aircraft flooring moulded from resin-bonded plywood by the Duramold process.

Among the advantages gained by the use of plywood aircraft parts and assemblies is a type of structure which has a high strength weight ratio and which is not affected by moisture, fungi and other deteriorating influences which caused glued plywood to be unsatisfactory. Panels and structures having the same weight as those made from light metal alloys, such as Duralumin, for example, have greater buckling strength because of their greater thickness, and resistance to buckling is often the critical factor. Freedom from rivets makes for smooth exterior surfaces, and this, together with less tendency to buckle and to form rippled surfaces, tends to reduce drag and to yield higher speed for a given power. Rapid fabrication from materials which are relatively plentiful and by those used to working in wood (hence not requiring skill in metal working) bring obvious advantages, especially in time of war. It is not expected, of course, that the resin-bonded plywood structure will displace the all-metal type, but it appears likely to supplement it on a large scale.

World's Industrial

CHEMICAL

Transparent containers for hydrofluoric acid are considered by Holm in a past issue of *Chem. Fabrik*. The author points out that glass vessels may be used for the absolute acid, but that, in practice, it is extremely difficult to realize the requisite conditions. Trolitul, a polystyrol resin, however, has shown itself ideal for the purpose. For apparatus construction, where resistance to hydrofluoric acid is necessary, this resin is available in the form of transparent sheets, tubes and rods. It is noted that Trolitul may be sealed to glass or metal with shellac, and that its maximum working temperature is limited to 60 degrees C. **Interesting to nickel platers** is the "Filtomesh" special type rubber mesh material developed by the Paramount Rubber Service, Inc., of Detroit. It is interposed between the plate and the filtering medium and is claimed to reduce cleaning operations and costs, to remove an increased amount of solids, and, where the filter cake is the primary product, to permit a 50 per cent. increase in output. It is of particular value in conjunction with bright nickel-plating vats. **Plastic coatings resistant to concentrated sulphuric and nitric acids** have been developed from thermo-plastic synthetics by the American Concrete and Steel Pipe Co., of Los Angeles. They are described in a bulletin recently published by the company. A list is given of some 15 industries where the coatings have found valuable use. **Machined Plexiglas** constitutes the bulk of the assembly in the new Milton Roy pump for handling dilute acids, hypochlorites, and other reactive chemicals. Not only is the material resistant to such reagents, but the permanent transparency of the pump body facilitates supervision; valve action, pump-piston operation and liquid flow can be kept under constant observation. Inlet and outlet conduit nipples are fabricated in plastic, whilst the piston is cast in a corrosion-resistant hard-wearing nickel-base alloy (Hastelloy C.). Pumps are available in capacities from 0.5 to 20 gallons per hour, the 18-gallon type, operated by a 1/6 h.p. integral-gear motor, being capable of discharging at this rating against a head of 150 lb. per sq. in. **The Braun Shell-design sulphur determination apparatus** manufactured by the Braun Corporation of Los Angeles, employs a Bakelite panel upon which are mounted the control instruments for the electric-furnace unit. The apparatus is designed especially for oil and other petroleum products and operates by volatilization and subsequent oxidation of the sample, the sulphur being absorbed and estimated as sulphate.

ELECTRICAL

Special switch casing in phenolic resin is a feature of the manually operated control for fluorescent lamps manufactured by the Jefferson Electric Co., Bellwood, Illinois. The grade of resin used is both heat and damp resistant and of high resistivity. The unit, which contains controls both for the "starting" filament and for the main circuit, measures, for the single-lamp size, 1.375 by 1.125 by 1.0625 ins. The use of plastics for this comparatively complicated unit not only enables the mechanism to be confined to a reasonable bulk, but renders possible its production at a competitive price. **Light-diffusing media** made from urea-formaldehyde and thermo-plastics are becoming very popular and are suitable for certain applications, according to *The Electrician*, April 18. Plastics vary in nature from transparent to opaque and some have a high transmission factor to ultra-violet light. When designing lighting elements embodying plastic materials, care should be taken regarding the proximity of electric lamps, due to temperature rise, resulting in discolouring, softening and decomposing. The light-transmission factor for one urea-formaldehyde is given as 35 per cent. for a thickness of 0.04 in. **Plastics for electrical measuring apparatus** must be selected with care, according to Lieneweg, writing in a recent issue of *ETZ*. The author points out the danger of acid formation from high-sulphur rubber mixes and the damaging effect such acid films may have upon suspension wires, reflecting surfaces and resistance coils, particularly where acid formation is assisted by the pressure of excessive moisture in the air. Less obvious is the danger which may result from the use of powerful accelerators, such as hexamethylendetramine, which may, according to the author, cause corrosion difficulties. He recommends the use of accelerators other than this particular substance. The hygroscopic qualities of natural lac have been observed to cause slow response from apparatus the coils in which have been insulated with silk impregnated with this material. The use of cellulose esters as insulating films has resulted in the elimination of this unwelcome phenomenon.

GENERAL ENGINEERING

The machining of plastics may be complicated by the abrasive quality of the fillers used and by the damaging effects of overheating at the surface being cut. The use of hard-metal tools ensures the maintenance of a keen cutting edge, and hence the avoidance of poor surface finish and undue heating, even with highly abrasive fillers. Cooling may be by compressed air. The subject is discussed in detail by H. Frank in a past issue of *Werkstatt and Betrieb*. Cutting speeds should be high; the greater they are the greater may be the feed selected. **Welding of thermo-softening plastics** has already been referred to in these pages. Further information contained in *Autogene Metallbearbeitung* is of general interest to structural engineers. It is pointed out that, apart from various types of gas-heated torch, an electrically heated "air-torch" is also available. Welds may be of single or double V types, the plastic filler being in the form of a wire. It is also pointed out that the softening of the surfaces to be joined occurs very rapidly, owing to the poor thermal conductivity of the resins, hence care should be taken to avoid sharp corners or edges, in order to minimize danger of overheating or burning. **Drilling of synthetic resins** demands for maximum output and minimum tool wear the use of specially adapted drill forms. Sachsenberg and Klein, in *Maschinen Bau Der Betrich* summarize the results of prolonged investigations carried out on a variety of commercial types of resin. In particular, the effects of point angle variation, clearance and helix angle were examined in relationship to surface finish. It was shown that, for drills with long helices (0-18 degrees) the cutting angle should lie between 60 degrees and 95 degrees for laminated and cast plastics, whilst for helices of 33-45 degrees, laminated plastics demand a cutting angle of 90-110 degrees, and cast resins of 90-100 degrees. **Horn radiator** made of resin-bonded plywood and lined with copper sheet is described in *The Engineer*,

...mploys Plastics

April 18. It was constructed by the Massachusetts Institute of Technology for the production of landing beams capable of helping aircraft to land in unfavourable weather. **A "conditioning" tank** constructed of resin-bonded plywood and about 8 ft. by 8 ft. by 18 ins. in size, is employed by a large concern of plywood manufacturers in London for conditioning and stripping the plywood of surface paper. The tank, which is built up of 1-in.-thick plywood, holds well over 500 gallons of hot water, and has been in service for some years with excellent results.

BUILDING

Wall coverings in laminated plastic were fast being exploited in pre-war Italy, according to an anonymous correspondent in *Materie Plastiche*. Great attention is being paid to the possibilities of achieving interior schemes fully in keeping with current taste and architectonic concepts, whilst it is pointed out that for walls, ceilings and floors the laminated plastics are mechanically strong, stable to atmospheric influences and permanent in form and dimension. Cabinets may also be constructed in plastics to harmonize with the main decorative scheme, whilst for indirect lighting systems, ceilings and cornices in plastics offer special advantages. For decorative motif, metal sections or corner pieces may be employed. It is not pointed out that the use of metal in this way contrives to bring out the full value of the plastics, providing a contrasting texture and colour which considerably enhance the decorative effects obtainable even from the simplest design. **Wear-resisting laminated flooring** for use more especially in goods lifts is manufactured from Laminoid by the Mica Insulator Co., Schenectady. Laminoid itself is stated to be made from Bakelite laminating varnish. The flooring compound is non-skid and has been shown to possess a wear resistance more than three times that of wood. **Corrosion-resisting cement** based on self-hardening synthetic resins are marketed by the Penn Salt Manufacturing Co., Philadelphia, under the trade names Asplit and Causplit, designed respectively to withstand acid and caustic attack. They are also suitable for use in contact with certain fluorine compounds and some organic solvents. Primarily designed for bonding masonry, they may, however, be used as applied coatings for concrete and metal.

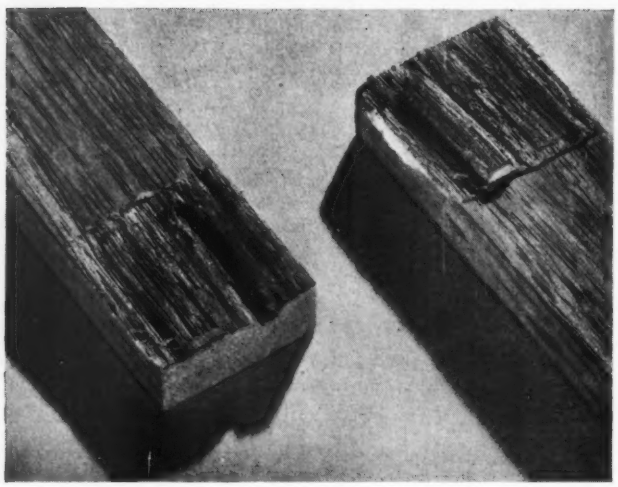
TEXTILES

Plastics in industrial hygiene constitute no innovation, but only recently has organized work been undertaken to determine, to some degree, quantitatively their efficacy in especially arduous or hazardous trades. Against skin irritants, solids, liquids, or airborn suspensions, Koroseal, Pliofilm and Vinylite fabrics have been demonstrated by numerous authoritative bodies in U.S.A. as valuable guards. Similarly, neoprene-coated fabrics and Synthal synthetic-rubber garments have proved their worth under industrial conditions. **Sodium alginate solution,** made from the organic acids derived from seaweed, has been suggested for the fabrication of textile fibres. The solution is extruded through fine spinnerets into an acid coagulating bath. The yarn so collected is hardened and rendered insoluble by treatment with special chemicals such as beryllium salts. The yarn is claimed to be quite strong.

MISCELLANEOUS

Rolls in printing machinery, formerly made exclusively from natural rubber, exhibited a high mortality due to the destructive action of solvents in the inks. The cost of such rolls being high, premature discarding resulted in unnecessary expense. Perbunan, a synthetic of the Buna group, overcomes these difficulties, according to an account which appeared in a past issue of *Rdsch. Dtsch. Techn.* Pure Perbunan mixes were compounded to give rolls possessing the mechanical strength of natural rubber, high immunity to oils and hydrocarbon solvents and the "softness and plasticity" of glycerine-gelatine pads. Where less resilient rolls were required, Perdurene, suitably vulcanized, was found satisfactory. Not the least advantageous feature of these materials for the purpose in view is their impermeability to coloured printing inks. **Process blocks in synthetic resin** are described in a recent issue of *Z. Dtschld. Buchdr.* It is pointed out that original blocks cannot yet be produced in these materials, but that they are ideal for duplicating from metal originals. For running off large numbers of copies, particularly for daily paper work, they are economical, as, unlike metal stereos, they may be produced in the flat form and bent to fit the rolls. Furthermore, they are said to give better transfer of colours to the paper and are capable of taking the finest impressions from the originals. As many as 100 stereos can be taken from one matrix without the sharpness of the latter being lost. For special purposes, a single stereo can be taken from a group of matrices. The stereos themselves have been tested out exhaustively and, even after a run of 100,000, show no undue signs of wear. **Tennis-racket strings** in nylon represent the latest application of this ubiquitous material. The development is rendered possible by the successful evolution of a so-called "giant strand" by E. I. du Pont de Nemours and Co. Inc. The strands, which are about 0.0625 in. diameter, are claimed to be exceptionally durable under mechanical stress and to be little affected by water. **Two-coloured mouldings in phenol and amino plastics** were discussed by Cordonnier in a late issue of *Rev. Gen. Matieres Plastiques*. The author quotes, *inter alia*, a simple dishlike form, such as is widely employed in the cosmetic and perfumery trades. If, for instance, such a container be required with a white interior and a red exterior, the outer envelope is first moulded and then, without removing this from the die, the white lining is moulded on to it, the die punch being arrested before it has completed its full downward movement. Cordonnier also describes a system for the production of metal inlay in plastic bases, the moulding operation being interrupted before the completion of pressing in order that the metal insert may be placed in the die. The author advises great precautions in the setting of large metal inserts in plastic bases, as ageing of the latter may result in the metal part becoming loose. He recommends testing by submitting to prolonged heating at temperatures somewhat above those likely to be encountered in practice. **"Lucite" methyl methacrylate resin** has been adapted by the Defender Photo Supply Co., Inc., New York, for use in making darkroom light filters by introducing enough colouring matter to produce the exact spectral transmission required and by incorporating adequate diffusing material.

Urea-formaldehyde Adhesives in Plywood Manufacture



It is indeed fortunate that in war-time we have in the phenolic resin glues and the newer urea resin glues materials far superior to the older types and, moreover, indigenous to this country

Shear strength tests show that the specimens of wood joined with urea resin adhesives break through failure of the wood at loads of 1,500 lb. per sq. in.

PLYWOOD is playing an increasingly important role in many industries and has, in fact, become a major material of construction. Its value to the national effort has been recognized by the appointment, under the Timber Control, of a Controller for the Production of Technical Plywood.

Rapid progress with the new synthetic adhesives was made before the war in Germany, where the requirements of a large plywood industry gave a real impetus to their development. One of the most important of the new synthetic resin adhesives was Kaurit Glue W. This material, a urea-formaldehyde liquid glue, was introduced by the I.G. Farbenindustrie Aktiengesellschaft about 1933, and it quickly became established as the leading synthetic resin adhesive in Germany. This success was due to the fact that besides being well adapted to hot-pressing technique it could also be used at moderate temperature or even for cold setting work. Production speeds obtainable with Kaurit Glue W were greatly in excess of those reached with any other adhesive.

Developments in Great Britain followed rapidly, and there is now a considerable production of urea-formaldehyde adhesives in this country. In 1936 the I.G. Farbenindustrie Aktiengesellschaft arranged with British Industrial Plastics, Ltd., 1, Argyll Street, London, W.1, to make Kaurit Glue W in England and sell it under that trade name. The necessary details of manufacture were supplied, and since 1937 all Kaurit Glue W sold in this country has been made here. To make a clear distinction between the German product and that made in this country British Industrial Plastics, Ltd., has renamed the product Beetle Cement W.

More recently, and as a result of the research work carried out by the firm's own chemists, a further cement has been introduced to meet the requirements of other industries, while a dry powder form of Cement W has also been produced.

The adhesives are never used by themselves, but always in conjunction with a "hardener" which is either mixed with the glue just prior to use or applied to one surface to be joined, the adhesive being applied to the other surface. The function of the hardener is to bring about a chemical and physical change in the adhesive leading to its gelatinization and subsequent hardening. In this respect synthetic resin adhesives differ from ordinary glues made from hides, hoofs, fish, etc., all of which make a bond by the purely physical changes taking place in them as they dry, no change in composition occurring.

Different Hardeners for Different Methods

Beetle Cement W is most commonly used for the manufacture of plywood, and because of its speed of setting, strength, resistance to moisture and mould attack it is an ideal adhesive for the purpose. Hardeners are available for presses operating under the following conditions, according to the requirements of individual manufacturers:—

(1) Steam-heated presses operating at temperatures above 90 degrees C.

(2) Hot-water veneering presses operating at about 50 degrees to 70 degrees C.

(3) Cold-pressing.

The mixture of glue and hardener is applied thinly and evenly to alternate surfaces of the veneers comprising the plywood assembly. Spreading machines with finely grooved metal or rubber rollers are generally used. The glue mixture may be applied to both sides of the centre-ply for three-ply work, or the two surface veneers may be spread each on one side only and an uncoated centre-ply interposed in assembly.

Pressing times depend on the temperature and on the hardener selected. Pressure may be as low as 40 lb. per sq. in. or up to 200 lb. per sq. in., according to the plant available.

The ordinary hardeners give plywood with very good resistance to cold water, and samples of plywood have

been kept for years exposed to the weather without any delamination or failure of the glue layer. This degree of durability leaves nothing to be desired for normal service in temperate climates, but for special applications or for use in tropical climates even greater stability can be obtained. By means of special hardeners the glue joint can be made highly resistant even to prolonged boiling in water. British Industrial Plastics, Ltd., has recently introduced a powder hardener under the name Hot Hardener 12 (patented), and this hardener is capable of giving joints with outstanding resistance to water. The powder and glue are thoroughly mixed in proportions 1 : 10, and the mixture is spread on the veneers by the technique described above. Pressing is carried out hot (90 degrees to 100 degrees C.) at 40 to 200 lb. per sq. in. Temperatures below 90 degrees C. are not recommended with this hardener. The plywood obtained is of a quality complying with the requirements of Air Ministry Specification 5V3, which calls for a three-hour boiling test. In an earlier specification (4V3) the minimum shear-strengths were given as 200 lb. per sq. in. dry and 100 lb. tested wet after three hours' boil. Beetle Cement W and Hot Hardener 12 gives figures of over 300 lb. per sq. in. dry and over 200 lb. per sq. in. tested wet after three hours' boil. The present specification contains no test for shear, but plywood glued with the above mixture complies with all its requirements.

Demands of Aircraft Plywood

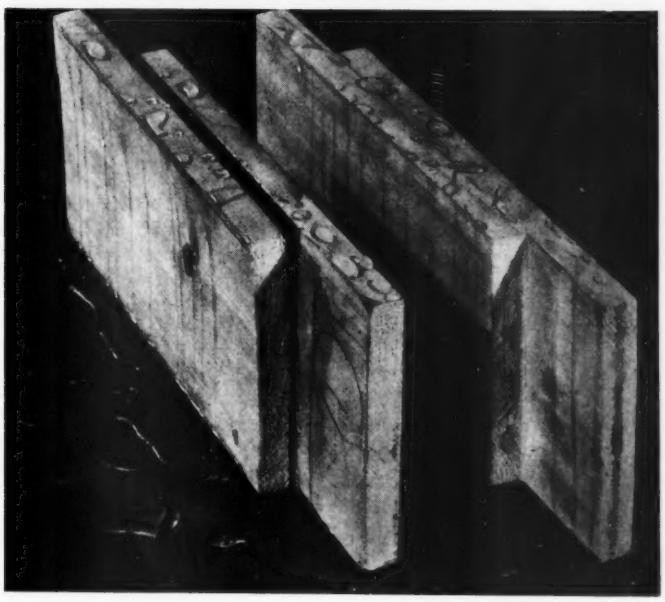
Plywood for lightly stressed parts of aircraft to specification D.T.D.427 can be made from Beetle Cement W and either hot hardener liquid or cold hardener white, and these materials are approved by the Ministry of Aircraft Production for the purpose. If temperatures of 90 degrees C. or more can be attained in the press, even better results can be obtained with Hot Hardener 12. The latter hardener is the only one approved for plywood of 5V3 quality.

The use of Beetle Cement W in plywood manufacture is not limited to the highest class of work. For many purposes there is no need for a cement which is fully waterproof, and in such cases the Beetle Cement W is extended with rye flour. This reduces cementing costs appreciably, whilst still giving a glue line of excellent strength. The water resistance of such joints is not so high as that of those made with the pure cement, but is better than is obtained with many competitive adhesives.

New Powdered Glue

Beetle Cement W is in liquid form, and if stored for more than three months becomes difficult to spread owing to an increase in viscosity. The manufacturers, therefore, stamp every batch with an expiry date, after which the material should not be used. This limits its use for export and prevents users from holding large stocks against an emergency. To overcome this, British Industrial Plastics, Ltd., has recently introduced a powder form under the name Beetle Cement H. The dry powder may be kept for over a year provided that it is kept cool, and it only requires to be mixed with the appropriate quantity of cold water to regenerate a liquid glue having all the desirable properties of Beetle Cement W. The liquid glue is used with hardeners exactly as described for Beetle Cement W.

Beetle Cements are really waterproof. As will be seen from the accompanying photograph a few weeks' immersion—



—in water has broken down the casein joint (left). The Beetle Cement joint (right) remains perfectly strong.

The principal technical advantages of urea resin adhesives in the manufacture of plywood are:—

(1) Low pressure and low temperature pressing conditions enable many ordinary veneering presses to be used in the production of high-quality plywood.

(2) Ordinary air-dried veneers are being used with complete success, irrespective of slight differences of 1 or 2 per cent. moisture content. Urea resin adhesives are initially water soluble, therefore strict control of moisture is not necessary.

(3) Owing to the lower temperatures and pressures employed urea resin bonded plywood suffers little "burnishing" or "case-hardening" of the surface veneers. Consequently it is easy to glue in subsequent operations and does not require sanding to open up the surface. This is of considerable importance in aircraft construction.

ADHESIVES and CEMENTS

In our January, February, March and April issues, the author completed the sections under phenolic and urea-formaldehyde resins, nitrocellulose and cellulose acetate cements and polyvinyl, polystyrol and glyptal types. In the following pages he deals with rubber adhesives and the bonding of rubber

By
E. E. HALLS

Chlorinated Rubber and Synthetic Rubber Adhesives

THERE is no relationship between the nature and physical properties of these two materials, but their uses in conjunction with one another justify treatment together. Chlorinated rubber as available to-day is an inert, stable, high halogen content material. It is a fluffy white powder, soluble in organic solvents, available in several grades that yield solutions of a range of viscosities. Synthetic rubber is a rubber-like material, on the Continent produced as the hydrocarbon butadiene (Buna), and in this country as the unsaturated halogen derivative neoprene.

A solution of chlorinated rubber in solvent is claimed to be a satisfactory adhesive for waxed paper. Solvents can be aromatic hydrocarbons (e.g., benzene, toluene, solvent naphtha) or halogenated aliphatics (e.g., chloroform). Solutions can be loaded with mineral matter (e.g., chalk, zinc, oxide, barytes, siliceous earth, clay, etc.), or asbestos, wood flour, or cotton flock, and employed as cements. Flexibility of the latter can be modified and improved by additions of semi-drying oils (e.g., pea-nut) or orthodox softeners akin to camphor, tri-phenyl or cresyl phosphate, etc.

Particular importance attaches to rubber-base adhesives by reason of their wide range of application and, more especially, in relation to their use for the bonding of rubber to metal. Imperial Chemical Industries, Ltd., has developed a chlorinated rubber known under the trade name of Alloprene, which has proved of great value as a bonding medium for rubber-metal joints, and is said to give bonds equal in strength to those obtained by the brass-plating technique (see *Light Metals*, 1940/3/175); it also appears to offer more extensive general possibilities than the latter method.

Application of Chlorinated Rubber

Chlorinated rubber can be used as a bonding agent for jointing thin metal sheets, metal to wood, metal to glass, metal to leather, etc., or the various materials to themselves. The chlorinated rubber is used in the form of a plasticized solution and is applied by brushing evenly over the surface of each face of the material to be jointed. The treated face is then allowed to dry to a tacky condition (approximately 20 minutes) and the surfaces to be joined placed together in a press and a pressure of 15-20 lb. applied for a short time. A typical chlorinated rubber composition would consist of:—Alloprene, grade B, 15 per cent.; gum ester, 10 per cent.; linseed stand oil, 5 per cent.; toluene, 70 per cent.

As stated in the first part of this account, " a favoured method for rubber-metal joints is to brass-plate the metal and then cure the rubber on to the plated surface. This technique requires special metal-spraying or plating equipment that may not always be available. The plated surface must be in perfect condition before application of the rubber mix, that is, the plating must be absolutely clean and free from grease and moisture.

" The old-established method of using an interlayer of ebonite, which gives satisfactory results for bonding rubber to metal, is not applicable to neoprene, unless the ebonite used is of the variety that contains a proportion of neoprene in the mixing. Observing this precaution, a bond can be obtained, but the strength is relatively low. Vulcabonds R and S, which give good results for bonding natural rubber to metals, are less satisfactory for bonding neoprene to metal, unless an interlayer of rubber is employed.

Rubber-metal Jointing

" The technique to be described later involves balanced mixes, and can be reversed, the rubber interlayer being bonded to the metal with Vulcabond. A further point is that the three methods discussed, viz., ebonite, neoprene ebonite, and the Vulcabonds, will not, even under the best conditions, give a heat-resisting bond, because the bonding materials are themselves thermoplastic.

" The Alloprene bonding technique is a highly effective method for bonding neoprene to nearly all commercial metals and alloys, including iron, steel and stainless steel, aluminium and aluminium alloys, magnesium alloys, zinc, and depends on the use of an interlayer of Alloprene (B) chlorinated rubber.

" The surface of the metal must first be thoroughly cleaned, e.g., by acid pickling, scouring or sand blasting, and must be entirely free from grease. It should then be given three successive coats with a solution of 30 parts weight of Alloprene (grade B) in 70 parts weight of xylene, drying between each application. The solution may be applied by painting, spraying or dipping. Just before the last Alloprene coating is completely dry, the calendered neoprene mix (which must have a perfectly clean and dust-free surface) should be laid on and rolled into contact by the standard technique used for such operations in the rubber industry.

" Vulcanization is then carried out, either in the press or in open steam. A temperature of 141 degrees C. is very suitable, but good bonds have been obtained at lower temperatures. With moulded articles, the mould should be cooled by plunging into water before opening, but there is no need to cool under pressure. It has been observed that the bond may be somewhat unstable until it has been cooled down for the first time, but, subsequently, the bond is quite stable up to a temperature of at least 120 degrees C.

" For the best results, the neoprene mix to be bonded should have a Shore hardness of between 50 and 75. Very hard or very soft mixes are less satisfactory unless a " tie gum " layer is used. The hardness of this layer should lie within the limits just mentioned.

" When large areas of metal are to be covered with

neoprene, the Alloprene layer is allowed to dry thoroughly, and is then covered with a solvent solution of the neoprene mix, the calendered neoprene sheet being placed in contact with this solution.

Rubber-to-Magnesium Bonds

" In many cases, and particularly with magnesium alloys, it is advantageous to mix 10-15 per cent. of red lead with the Alloprene. Such solutions must be well stirred immediately before use, as the heavy lead oxide settles out fairly rapidly. Except in the case of magnesium alloy, the red lead does not appreciably increase the strength of the bond but it does yield more even and more reliable bonds. Other oxides, such as litharge and zinc oxide, also give good results. The method may be used satisfactorily to bond neoprene to glass and vitreous-enamel surfaces as well as to metals.

" To obtain very strong bonds between rubber and metal, a technique involving the use of neoprene interlayers may be adopted. As opposed to the Vulcabond method, the results obtained show the advantage of being stable at high temperatures, e.g., 120 degrees C.

" The metal surface is cleaned and coated with Alloprene solution in the manner already described. A thin strip of calendered neoprene mix is then laid on, or a solution of the neoprene mix is applied. For a successful union to rubber, the sheet must be freshly calendered and preferably should be still warm. The calendered rubber mixing should next be brought into contact with the neoprene mix, or dried neoprene solution coating, and the whole assembly cured in the press or in open steam. The usual technique for removal of air bubbles in rolling the sheets into contact must be observed. In most cases it is not necessary to use an intermediate solution layer of the mixed neoprene and rubber stocks.

" For successful results, it is absolutely essential that the neoprene and rubber stocks should be balanced both as regards rate of cure and from the standpoint of volume loading of filler. (See B. J. Habgood, trans. I.R.I., 1937/13; No. 2/141). Medium to hard stocks having a Shore hardness of over 60 have given the best bond.

" The following is an example of suitably balanced mixes:—

Neoprene Stock		Natural Rubber Stock	
Neoprene Type E ...	100	Smoked sheet ...	100
Light calcined magnesia	10	Zinc oxide	5
Channel black (Kosmos T)	35	Channel black (Kosmos T)	40
Wood resin	5	Vulcafor M.B.T. ...	0.75
Cottonseed oil ...	3	Sulphur	3
Neozone A	2	Neozone A	1
Sulphur	1		
Zinc oxide	10		

(Cure—24 mins. at 141 degrees C.)

" The words ' Neozone,' ' Vulcabond ' and ' Vulcafor ' are trade marks registered in Great Britain, and are the property of British Dyestuffs Corporation, Ltd., a subsidiary company of Imperial Chemical Industries, Ltd. Data appertaining to the use of these is reproduced from Report N11, Imperial Chemical Industries, Ltd.

Vulcabond is the trade name (British Dyestuffs Corp., Ltd.) for special rubber derivatives designed for the bonding of soft rubber to metal during the actual vulcanization. Vulcabond is available in two grades, namely, R and S, and both materials bond rubber to iron, steel and a variety of other surfaces.

"Vulcabond R is a black, plastic material supplied either in the solid form (Vulcabond R solid) or dissolved ready for use in toluene as a 50 per cent. solution (Vulcabond R).

"Unlike other thermoplastic rubber derivatives of this class, Vulcabond S is manufactured from latex. It is dark brown to black in colour, hard and tough, although somewhat brittle under impact at room temperatures. It softens between 60 and 100 degrees C. and finally melts at a temperature between 280 and 300 degrees C. It is soluble in the usual rubber solvents, such as solvent naphtha, benzene, xylene and chlorinated solvents, such as trichlorethylene.

"In addition to bonding natural rubber, Vulcabond can also be employed with synthetic rubbers based on butadiene. Neoprene cannot be bonded with Vulcabond, but other bonding materials are available.

"Vulcabond is designed for the bonding of the unvulcanized rubber to metal during the vulcanization process, but it will often produce adhesion between vulcanized rubber and metal. This adhesion is considerably less than that obtained during vulcanization, and Vulcabond R gives better adhesion with vulcanized rubber than Vulcabond S. Owing to its greater resilience, Vulcabond R is to be preferred when vibration is likely to be encountered in service. For all other purposes Vulcabond S should be used. Both materials are thermoplastic, and the bonds they furnish are therefore only suitable for service at temperatures not higher than 60 degrees C.

"Vulcabond is applied in solution form to the surfaces to be bonded. For general purposes Vulcabond R should be used as a 50 per cent. solution, although anything between 30-70 per cent. is permissible. Vulcabond S should be employed in a 10-20 per cent. concentration.

The Vulcabond Technique

"The metal surface to be bonded must be clean and free from grease and scale. For the best results it should be cleaned after degreasing by acid pickling, scouring or sand-blasting. A thin, even coat of Vulcabond is then brushed or sprayed on both the metal and the rubber. At least two coats should be applied, the first being allowed to dry before the application of the second. Unless there be a good, even coating of the active Vulcabond, a uniform bond will not be obtained, and, consequently, as many as six applications may be necessary, depending on the skill of the operator.

" When the final coats are tacky the surfaces to be bonded are brought into intimate contact, care being taken to remove all air bubbles by rolling outwards in the usual manner. The built-up assembly is then vulcanized. For the best bonds, press cures are necessary, but adequate adhesion is obtainable with open steam cures.

"The cure should be as lengthy as possible. A soft, lightly loaded rubber stock gives the best results. Where hard or heavily loaded stocks are to be bonded a tie gum of lightly loaded rubber is often essential and will always give better results. Stearic acid and paraffin wax should be kept as low as possible, as these materials tend to bloom out on to the surface and interfere with adhesion.

"The accelerator used in the rubber mixing has some effect on bonding strength. Accelerators may be graded in the following descending order of merit: Vulcafor DPG, DA, ZDC, MBT, BA, TMT.

"It is advantageous to cool the bond slowly. It should be allowed to rest at least 24 hours before being put to any severe strain.

"When large areas have to be covered the Vulcabond sometimes dries too quickly. It is necessary, therefore, to slow up the drying so that tackiness can be maintained long enough for the required manipulation to be carried out. Addition of small amounts of high-boiling plasticizers, such as tricresyl phosphate, enables this to be done. The following table shows the effect of tricresyl phosphate on a 10 per cent. solution of Vulcabond S in benzene.

Tricresyl phosphate, per cent.	Drying criteria.
Nil	Dries in a few secs.
1	Delays drying for 15 mins.
5	Delays drying for 1 hr.
10	Delays drying for 16 hrs.

" Other plasticizers and high-boiling solvents can be used, provided they mix with the solution.

"In the bonding of vulcanized rubber to metal, wood, concrete, leather, etc., the bond is made in much the same way as an ordinary glue joint—i.e., when most of the solvent has evaporated and the surfaces are tacky, the bond is made by rolling from the middle outwards to remove air bubbles and keep under pressure for at least 12 hours. The adhesion obtained with vulcanized rubber is not nearly as strong as that obtained with unvulcanized rubber cured on to the metal with Vulcabond, but it is often sufficient for practical purposes. Vulcabond R usually gives better results than Vulcabond S with vulcanized rubber.

"By heating the metal with a blowlamp to about 100 degrees C. before applying the Vulcabond, much better adhesion can often be obtained. This can be further improved by painting the surface of the rubber with a dilute solution of sulphur chloride (about 2 per cent. in benzene) immediately before bringing it into contact with the hot metal, which has been painted with Vulcabond. After sticking down, the rubber is 'sweetened' by wiping over with dilute ammonia solution. This method also enables vulcanized rubber to be bonded to aluminium."

The Reanite Process

A further medium for the bonding of rubber (in various forms) to metal is Reanite, manufactured by the Reanite Corporation of Canada and marketed in Great Britain and the British Empire by Monsanto Chemicals, Ltd. Reanite is described as a synthetic resin and is produced in various grades. It is applicable to the bonding of rubber to a wide variety of materials, including aluminium, with which metal no preliminary brass plating is required, and with which exceptionally strong adhesion is said to be obtained.

Details of the Reanite technique are, unfortunately, not available to the author at the moment. It is stated, however, to bond, by cold application, vulcanized—or unvulcanized—or latex, rubber to various metals and non-metals, giving excellent strength, even without the application of pressure. By the use of heat and pressure, maximum adhesion strengths of 800-1,200 lb./sq. in. may regularly be obtained in production, the assemblies being resistant to temperatures up to about 150 degrees C.

Some indications of the properties of the rubber-metal bond obtained with Reanite are furnished by the table given below, although data referring specifically to rubber-aluminium joints are not available.

The testing procedure employed are similar to that specified by the American Society for Testing Materials. Discs of rubber, ½ in. (12.7 mm.) thick were vulcanized between steel discs 2 sq. ins. in area (12.9 sq. cm.), cleaned by sand-blasting and then coated with Reanite cements. The direct pull necessary to tear the assembly apart was then determined (a) at room temperature, (b) immediately after immersion in boiling water for 5 mins., (c) immediately after heating for 30 mins. in an oven at 149 degrees C. The following results are typical, although in a considerable number of cases still higher figures have been obtained.

Test Results on Reanite

Coats of the following Reanite cements were applied to the steel in order, viz., Nos. 1-111A, 2-112B, 3-201A.

Hardness of the rubber (Shore).	Strength of the assembly. At room temp.	At 149° C.
50	1,885 lb.	360 lb.
60	1,912 lb.	367 lb.
50	1,890 lb.	312 lb.

Monsanto Chemicals, Ltd., has indicated that one particular variety of Reanite is suitable as a protective coating, especially for magnesium. No information has yet been published regarding the use of Reanite cements as adhesives for magnesium, but it is to be presumed that they could be satisfactorily employed in this way.

An interesting synthetic rubber emulsion contains the following ingredients:—

	By weight.
(a) Synthetic rubber	13.2%
Petrol	39.34%
(b) Casein (acid precipitated)	5.4
Oleic acid	0.34
Ammonia	1.45
Water	Remainder
	100.0%

The synthetic rubber is dissolved in the petrol, and the casein and oleic acid in the water with the assistance of the ammonia. The two solutions are mixed by adding (a) slowly to (b) with vigorous stirring.

(To be continued.)

ARCHITECTURE AND PLASTICS.—On April 5, a B.B.C. broadcast was given by the well-known architect, Mr. G. Grey Wornum, F.R.I.B.A., on the subject of " Plastic Possibilities." The speaker was enthusiastically in favour of their proper use in architecture and told how the war effort has taught us a great deal about what can be done with plastics. Partial plumbing in plastics is already being employed in the interests of saving metal. America has gone a long way in experimenting with complete plastic wings and parts of the fuselage for aeroplanes for purposes of mass production. Electric heating wires have been successfully embedded into laminated sheet for de-icing wings, and this idea may well develop in post-war days for heating panels for rooms and cupboards, even for heating bed ends. If large aeroplane parts can be so produced it will be but a step further to make in plastics whole sections of our homes as mass-produced units.

The resin treatment of wood veneers and decorative papers and metal foils again opens up an enormous vista of decorative possibilties for building after this war.

PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

MELAMINE RESINS.—In March, 1938, we first encountered moulded goods of melamine resin at the Venditor stand at the Leipzig Fair. Readers may remember our comment on their beauty and our hope that such resins would one day be introduced into this country. We have now much pleasure in announcing their manufacture by British Industrial Plastics, Ltd.

The ultimate raw material for its manufacture is calcium carbide, which is converted by heat and atmospheric nitrogen into calcium cyanamide and then dicyandiamide, which is turned into melamine by treating with ammonia. On the Continent, the production of melamine is carried out under high pressure, but British Industrial Plastics, Ltd., has developed a patented process which does not employ expensive high-pressure plant and is capable of giving 90 per cent. yields.

Melamine dissolves readily in formalin when heated, and methylol melamines are first formed in the solution, from which they may be isolated by low-temperature evaporation. If heating is continued condensation occurs with the production of synthetic resin. The resin is water-white, very rapid hardening and resistant to heat and water. Melamine resins have the advantage over the earlier aminoplastics (urea/formaldehyde and thiourea/formaldehyde) that they are much more resistant to heat and to moisture whilst retaining the characteristics of freedom from colour and odour, light stability and resistance to electrical " tracking."

The applications of these new resins which have been proposed are very numerous. Quite a number have been taken beyond the development stage and are now in production. On the continent of Europe, just prior to the outbreak of war, moulding powders made from melamine resin were on the market and were particularly recommended for such applications as tableware and bathroom fittings, such as shower-heads, because of their exceptional water resistance. In the U.S.A. melamine resins have been developed principally for laminated sheet in applications such as refrigerator panels and for lacquers and enamels. Melamine resins allow of the production of extremely hard marproof finishes, with much shorter stoving schedules than have previously been possible. Owing to the colourless nature of the resin and its resistance to discoloration by light and heat, melamine resin is the obvious choice for pale-coloured finishes, and it is already proving very popular for this class of work.

In this country the Beetle Products Co., Ltd., has developed the use of melamine for lacquer resins and also as a hardener for synthetic resin glues. The latter application, which is protected by patent, is of considerable interest at the present time because of its importance in the plywood industry. Urea resin glues have long been used as the adhesive in the better qualities of plywood and are sufficiently waterproof for ordinary conditions of humidity and temperature. For tropical conditions or continuous contact with water a higher degree of water resistance is necessary, and this is provided for in Air Ministry Specification 5V3, which includes a three-hour boiling test on the plywood. By the use of a melamine hardener, urea resin glues are capable of giving plywood complying in full with the provisions of this specification, and this result can be attained at temperatures of 100 degrees C., and pressure as low as 40 lb. per sq. in. The only alternative glues for the manufacture of this highly water-resistant plywood are those of the phenolic type, which require much higher pressures and temperatures, necessitating the use of special presses.

PLASTICS FROM STARCH.—In the March issue of *Modern Plastics*, J. Seiberlich describes some of the work that is being carried out in the U.S.A. on the production of films and plastics from starch, the raw material for which is the potato.

Judged from an economic agricultural point of view there are considerable advantages over the use of wood, since potato crops are harvested yearly and wood pulp is only available from the tree after 15 to 25 years' growth. Starch as a raw material for transparent wrapping film manufacture is interesting, for glass-clear starch films can be obtained by preparing the starch solution and allowing it to dry. No setting baths, etc., are required, as is the case in the " Cellophane " process. Much work has been done in investigating the preparation and properties of starch films, and more work is still required to secure successful commercial production.

F. D. Farrow and E. Swan have prepared films in order to study the water absorption of the dried films. They have obtained thin non-adherent sheets of cooked starch by drying pastes on very slightly greased plates of aluminium and other materials. These films, according to the authors, were transparent, white and flexible under ordinary atmospheric conditions.

Starch is also a potential raw material for two hundred plastics of the moulding type. Stolle and Kopke have shown that a reaction between starch and formaldehyde takes place, resulting in a so-called formaldehyde starch, which has lost most of its paste-forming property. While all of these experiments have dealt with rendering starches insoluble, the Herold A.G. claims the use of such starches for casting plastics. For this purpose, starch is brought into reaction with formaldehyde in the presence of accelerators, as, for instance, lactic acid, phthalic anhydride, and the like. The semi-liquid mass is poured into forms and allowed to harden. I. Thorn went one step farther and incorporated urea with the formaldehyde starch to produce moulding powders.

SOLVENTS.—The second edition of Dr. Otto Jordan's book " The Technology of Solvents " (Leonard Hill, Ltd., London. Price 25s.) has just appeared. We consider this book the best in the field, and it has been admirably translated by Mr. Alan Whitehead from the original German.

We need scarcely repeat our reminder of the importance of the information given in this book to the plastics industry itself, although generally speaking it is intended for the paint, varnish and lacquer industries. The increasing use of the phenolic resins for impregnation of paper and wood, and of the thermoplastic resins as films, coatings, impregnations, cements, etc., makes a sound knowledge of solvents and solutions imperative. The author's description of the mechanism of solution is among the clearest we have yet read.

This edition remains broadly the same as the first edition, but includes a number of solvents which were not mentioned previously and pays more attention to solvents and plasticizers for the new synthetic film-forming materials such as cellulose ethers, chlorinated rubber, polyvinyl resins, etc.

DISTRIBUTION OF STEEL SUPPLIES.—The Iron and Steel Control's booklet, "Distribution of Steel Supplies, No. 3, Customers," directed that application for steel authorizations should be addressed to the Government Department under whose responsibility the steel was to be used. From now on, applications from certain raw material industries will be dealt with by the appropriate controller.

In the case of plastics, application forms for authorizations of steel for:—

(1) The manufacture of new plant and machinery;

(2) The maintenance and repair of existing plant; and

(3) Packages and containers,

to be used in processes of manufacture of plastics can be obtained from the Controller of Plastics, Great Burgh, Epsom. The processes referred to are:—

The production of moulding powders of all descriptions and articles made therefrom; of synthetic resins of all descriptions (other than alkyd resins) in the form of powders, lumps, granules, sheets, rods, tubes, films and foils; of materials in the form of sheets, rods, tubes, blanks, films and foils (other than cinematographic and photographic film base, whether sensitized or not) manufactured from nitrocellulose, cellulose acetate or rennet casein (whether hardened or not).

Applications for steel for building should also be referred to the Control in the first instance, although, except in cases of new building wholly or partly financed by the Ministry of Supply, authorizations will be issuable by the Ministry of Works.

Company Notes

MAY AND BAKER, LTD.—This concern announces that it has incorporated a separate company, M. and B. Plastics, Ltd., to take over the business, as from April 1, 1941, of the Rhodoid department.

The Board of the new company is constituted as follows:—

Mr. G. C. Bell, Managing Director.
Dr. T. B. Maxwell, Mr. R. W. E. Stickings, Mr. C. A. O. Rideal } Directors.
Dr. K. G. A. Cock has been appointed Technical Manager.

BRITISH XYLONITE CO., LTD.—The Directors are pleased to report that all subsidiary companies have substantially increased their sales. Special attention has been paid to the export trade, and this side of the business has shown a satisfactory increase.

The accounts have again been delayed owing to conditions arising out of the war, and the Directors decided to pay Second Interim dividends on March 31, 1941, of 2½ per cent. on the 5 per cent. Cumulative Preference shares and 7½ per cent. on the Ordinary shares, making for the year 5 per cent. on the Preference shares and 10 per cent. on the Ordinary shares. These Second Interim dividends are intended to take the place of Final dividends, and the Directors do not recommend any further payment of dividends for the year 1940.

M. AND B. PLASTICS, LTD., was registered as a private company on April 10, with capital £1,000 in 1,000 shares of £1 each, to carry on the business of importers, exporters and manufacturers of and dealers in synthetic and natural plastic materials.

New Plant

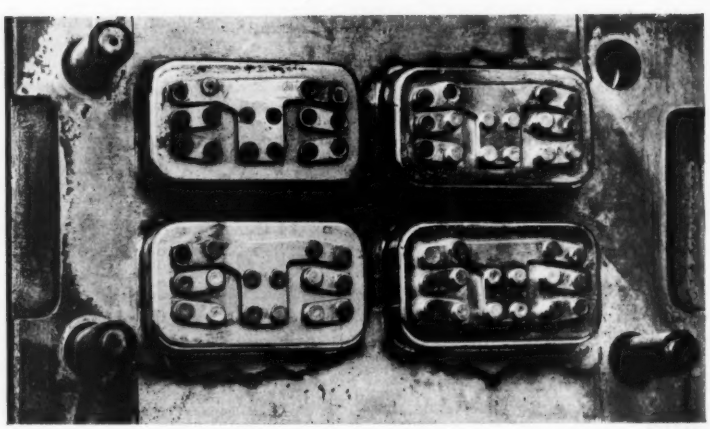
The Repair of Broken Dies

Left: An example of modern welding technique as carried out by the Eversharp Diamond Tool and Abrasive Co.

WITH the shortage of steel and the long period normally required for replacements it is of the utmost urgency for moulders to consider the possibility of repairing broken dies or moulds even when the job seems rather hopeless. We are reminded sharply of this matter by the examination of some of the extraordinary work by the latest welding methods of The Eversharp Diamond Tool and Abrasive Co., of Birmingham. Many of the moulders in this district are availing themselves of this method of repair, and we have seen examples of welding that have given a new life to broken dies.

The accompanying photographs show what can be accomplished. The first is self explanatory, while in the moulding die shown the raised flanges around the holes are seen to be broken. These are built up by Eversharp welding "as good as new."

Below: The complicated moulding die seen here is broken at flanges around the holes. Welding can repair this for a further period of life.



Inquiries and Answers

(In Which is Included General Correspondence)

IMPORTANT NOTICE: If inquirers wish to receive replies by post, a stamped and addressed envelope must be included in their letter. It is understood that the submission of a problem to the Editor permits its publication in this journal.

Plastics in Orthopædy

I have been engaged for some years in producing a system similar to dentistry for the manufacture of foot appliances. The moulds are of soft metal or plaster indurated with phenol-formaldehyde or dental stone. The moulding part of the process is satisfactory and with it can be produced models in thermoplastics and urea-formaldehyde impregnations.

Thermoplastics are most suitable since they can be preheated and pressed in cold moulds, they also can be adjusted by remoulding at a subsequent date.

Unfortunately, however, none of the following stands the strain, and fracture with time:—

Cellulose acetate (⅛th to 5-32nds thick).

Methyl methacrylate resin ⅛th, 3,32nds, 5-32nds. Good but brittle, wears longest, but ultimately snaps. Can be broken with the hands.

Vinyl resin (⅛th). Very tough, cannot be broken in the hands, resists beating in percussion press. All supports in vinyl resin, surprisingly enough, break the soonest in wear.

I have concluded that an acetate-fabricated plastic would retain its shape better and not fracture.

The obvious thing for tensile strength would appear to be urea-formaldehyde or phenol-formaldehyde impregnated papers with low temperature curing (in view of composition of moulds), but this cannot be remoulded at a subsequent date. For ease of moulding and reshaping thermoplastic is the best, but will not resist intermittent pressures. Is there any heat moulding and pressure cycle with thermoplastic which increases its strength, rigidity and resistance to fracture?

I have just recently come across an extract from *Modern Plastics* which illustrates a very similar process to mine. The plastic used in this instance is Tenite II in sheet form moulded by Insulation Manufacturing Co. This, of course, is American. Could you tell me if Tenite II is available in this country?

If you know the properties of Tenite II perhaps you can advise a very similar substitute.

I note in August, 1940, issue of *Plastics*, page 187, an example of Lucite acrylic resin arch supporters for shoes. These would seem to point to success with Perspex (acrylic), but whereas the Lucite is securely fixed at arch extremities, this does not obtain with a loose support. Perhaps Lucite has greater tensile strength than Perspex.

Can you suggest where I may obtain phenol-formaldehyde and urea-formaldehyde impregnated papers?

I shall be grateful if you are able to give any help in solving these problems. T. HOLLAND,

Leeds. Orthopædist.

[EDITOR'S NOTE.—While the inquirer's questions on the whole are clear, one or two are not. We do not understand, for example, his conclusion that acetate fabricated plastic would not fracture after his first assertion that it does fracture with time like the other materials. The breakage of vinyl resin is also surprising to us.

(1) There is no method of increasing the strength of thermoplastics by a moulding cycle. A suggested process might be the impregnation of a fabric, say, silk with any of the thermoplastics (suitably plasticized), say, cellulose acetate, methyl methacrylate, etc., in solution form. We do not doubt that a strong moulded shape could thus be made. To hide the appearance of the fabric on the surface the finished moulding could be sprayed with lacquer.

(2) The inquirer does not appear to have tried celluloid which is a very strong plastic. Perhaps the presence of camphor may be an objection, but advice should be sought from BX Plastics, Ltd.

(3) Tenite II is a cellulose acetate butyrate made by Tennessee Eastman Corporation, Kingsport, Tennessee. It is stated to be stronger than cellulose acetate and to possess the highest impact strength of all common plastics. (In passing it would be interesting to know how the foot appliances, presumably sole supports, stand up to the continual pressure of the weight of the body and the heat of the foot.) Cellulose acetate butyrate is not made in this country, and so far as we know is not, and is not likely to be, imported until the war is over.

(4) We do not believe that Lucite has a greater tensile strength than Perspex. They are basically the same.

(5) Phenol-formaldehyde resin impregnated papers can be obtained from Bakelite, Ltd., British Resin Products, Ltd., I.C.I. (Plastics), Ltd., Ellison Insulations, Ltd., Thomas de la Rue, Ltd., Samuel Jones and Co., Ltd. Urea-resin impregnated paper can be obtained from British Industrial Plastics, Ltd.]

The Waterproofing of Concrete

We have considerable demands for the waterproofing of concrete, and our efforts in the past, both with mixing special chemicals in the wet mix and by coating when dry, have not produced very good results. Are there plastic materials available which can be employed?

Leeds. S.S.T.

[EDITOR'S NOTE.—It is generally conceded that mixing waterproofing materials in with the wet mix is wasteful (since it is not necessary to waterproof the whole of the interior) and also may delay the setting of the cement. Application when dry with fair penetration (say ¼ in.) should be ample to give good protection. Generally speaking most impregnants are affected by any free lime present and if it were possible to neutralize the lime with dilute acid and to wash out the soluble salt, e.g., calcium chloride with water, theoretically, at any rate, most impregnating materials would be more satisfactory than they are. This also applies to the colouring of concrete. On the other hand, this does not always follow. The Government has advised the coating of concrete shelters with shellac solution. Not only is shellac water resistant but when it reacts with lime it forms a calcium soap which is also fairly water resistant. On the whole it would be advisable to choose one of the more or less completely inert synthetic resins. Of these coumarone resin would appear very suitable, preferably applied as a solution in, say, benzol or toluol. There are, of course, other resins eminently suitable, such

as polystyrene, but they cannot be employed if price is a consideration, which it always is.

Phenolic resins in alcohol or oil soluble types dissolved in white spirit, rubber, the synthetic rubbers and rubber-like resins dissolved in benzol or latex and emulsion forms, waxes, especially the more inert synthetic waxes made more adherent with certain softening agents, have all been used with some success.

Without doubt the so-called failure of impregnants is not always so much due to their own deficiency as water-repellants but to lack of understanding of the whole problem, including the fact that water from within and under high pressure can break films of considerable strength. Thus protection should be given also at points above ground level. The failure of even damp courses can sometimes be traced to omission of adequate treatment.]

Boiler Insulation by Plastics

We have followed the notes you have published on low-temperature insulation with great interest and would like to know whether plastic insulation of boilers is at all possible. The normal insulation used, e.g., asbestos and magnesium oxide held in place by wire netting or other means is not a very coherent structure, breaking away with resulting loss of heat. A rigid insulator seems to be the answer. A. G. AND CO.

[EDITOR'S NOTE.—This problem is almost the same as that described last month for low-temperature furnaces, and high-pressure boilers often reach temperatures higher than 300 degrees C. We do not believe any modern plastic will stand up to this temperature without complete breakdown. The problem might be satisfactorily solved by retaining the present insulation, that is asbestos-magnesium oxide mixtures, and protecting the outer surface with a plastic covering. The latter, since there would be little heat at this point, could be of thermoplastic or thermo-setting material. Presumably it could be sprayed on to get a continuous thick film round the insulation. Alternatively, sheets of, for example, cellulose acetate could be wrapped round pipes, etc., and sealed. In other words, the plastic here serves merely as a strong, flexible protection holding the loose insulations in place. It is very doubtful whether this protection would be considered worth the additional cost.

Even for hot-water systems with temperature as low as 80 degrees C. there are the same difficulties. Thermoplastics would still be of no use in direct contact with metal at 80 degrees C., although thermo-setting resins would be satisfactory from this point of view. Theoretically, a sprayed layer of resin covered with asbestos flock while the resin is wet and finally sprayed with resin to give a fairly smooth outer surface would appear to give a rigid insulator. Hot-water cisterns, however, which normally are kept in closed cupboards, lose little heat and need no insulation, because the air around them is more or less static and itself acts as an efficient insulator.

On the whole, high-temperature insulation does not seem a problem for organic plastics. Refrigeration, although also a matter of heat conservation, is by its very nature an entirely different proposition lending itself admirably to solid moulded plastics.]

Plastic Venetian Blinds

I wonder if you can help me by placing me in touch with the source of any photographs or illustrations dealing with the use of plastics in connection with the laths of venetian blinds.

I am preparing a very beautiful book, which will be the standard history, manual and textbook on the current practice for the production and finishing of venetian blinds.

In America plastics are used very considerably, and what are known as translucent laths are well known.

What I am seeking are some appropriate illustrations of any application of plastics in thin strips or slats which would be of help and interest to furnishers and blind makers who, at the right moment, will be developing up-to-date venetian blinds departments.

I have all the data and photographs regarding wood laths and metal laths, and as in time plastics may become more popular and attractive, I shall be very grateful if you can give me any help in getting hold of some illustrations and information relating to the development of plastics for this purpose, especially illustrations. EDWARD R. CROSS.

Manchester, 2.

[EDITOR'S NOTE.—We have never encountered a British-made plastic venetian blind, although a near approach to this idea was the moulded slat radio cabinet top made, we believe, by Crystalate, Ltd. The moulded slats were bonded on to a fabric backing, the whole resembling a roll-top for a desk. The inquirer is obviously referring to the laminated venetian blinds made by the Rex Co., Inc., Boston, Massachusetts (see photograph below), which received a First Award in the Modern Plastics

Competition. The slats were made of Laminoid, a laminated material made by the Mica Insulator Co. Impregnated with Bakelite phenolic resin, the material was probably a fine fabric, as the slats were translucent. Other advantageous claims made were ease of cleaning, fire-resistance, non-warping and high insulation during hot weather. Generally speaking, laminated material is the only suitable material for the job both from the point of view of strength and manufacture.]

American Friendship

I have just received a most charming letter from C. A. Breskin, publisher of the American magazine *Modern Plastics*, whom I asked to send me a copy of their 1941 Plastics catalogue. He says:—"We are not making any charge for the Catalog. We would like to have you accept this with our compliments and as an indication of the bond of friendship that exists between ourselves and our respective peoples."

I think this might interest you as a topical note.

I. M. EDELMAN, Managing Director,
British Plywood Manufacturers, Ltd.